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The manufacture of cement in the state of California

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THE MANUFACTURE OF CEMENT IN THE STATE OF CALIFORNIA

BY

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ILLUSTRATIONS

The present age of rapid transportation, due to the wonder child of the twentieth century, the automobile, has removed the matter of roads from a local affair and made us all nationally minded in regard to motor-able roads. We are now so road-minded that we associate hard surfaced roads and automobiles very much as we do hammer and nails or sleds and snow.

Hard surfaced roads immediately bring to mind concrete, which in turn echoes Portland cement, so a product that is so intimately associated with our economic and recreational life, is of more than passing interest.

In studying the subject of cementitious materials, from a structural standpoint, we find as we retrace our progress, that concrete as evolved, has always had the commanding position of superiority as a structural material, it now enjoys, in all stages of man's civilization.

The first use of concrete has been lost in antiquity and ante-dates the written history of man, however our earliest civilization have left evidences of their dependence and faith in concrete, as shown by their walls of defense, citadels, places of worship and monuments to posterity.

The discovery of the use of cementitious material, is a matter of romantic conjectures, and one naturally thinks of a civilization living in limestone or gypsum caves or grottos, with the perpetual fire at the entrance for safety or worship. The fire box or alter was built with the country rocks adjacent, which in most cases was limestone. Early man must have been interested in the decided change occurring in the rocks that were limestone, when subjected to the greatest heat, and later with the seasonal rains that reacted on the burned mass, to have noted how they consolidated into a conglomerate mass.

The only notable change in the quality of cementitious material as first made is to be found at the beginning of the Roman Empire, when they found that the addition of certain ejected flows from volcanos had a most beneficial effect when mixed with lime.

With the fall of the Roman Empire, the art of concrete construction was lost along with a good many other arts, and was not revived until the middle of the Eighteenth century (1756), but after its re-discovery, rapid strides were made in the development of better cement and concrete through scientific study.

The beginning of our present development of Portland cement really starts with the investigation by John Smeaton, who in 1756 experimented with lime made from local materials in the construction of the Eddystone Rock Lighthouse. He found that lime made from low grade limestone had more and better hydraulic properties than that made from pure lime.

Next in our march of progress we note Joseph Aspidin, an English brick layer, who in 1827 took out a patent to mix limestone and clay, "mixed to a state of approaching impalpability, calcining till the carbonic acid is entirely expelled." He gave to this product, the name of Portland Cement, on account of its fancied resemblance to the then popular "Portland" building stone.

The Germans took up the study of this new cementitious material and aided very materially in removing its manufacture from a rule of thumb control to a more exact science.

History next gives credit to Joseph Monier, a French gardener, who in 1868, found that by embedding steel in concrete in such a way as to take up the tensile stresses, the efficiency embodied the compressive strength of the concrete and the tensile strength of the steel. This discovery increased the uses of concrete many fold.

The next step of importance was the discovery and development of the rotary kiln, by John Ransome an English engineer. Mr. Ransome took out his patent in 1885 but was unable to interest any one for several years until a small plant in America, in the State of Oregon, became interested and made the first installation.

The rotary kiln finally became recognized standard equipment in 1895.

A chronoligical table for reference follows:

	A.D
Smeaton's researches on hydraulic limes and pozzolanas,...	1756
Aspidin's invention of Portland cement,......	1824
Reinforcement of concrete proposed by J. C. Loudon,.	1830
First German Portland cement works at Settin,	1850
First employment of reinforced concrete,.....	1855
Hydraulic properties of granulated slags discovered by E. Langen,........	1862
Ransome's invention of rotary kiln,..........	1885
Introduction of tube-mills by F. L. Smidth,..	1892

The study of Portland cement manufacture as developed in California, reveals several outstanding details of interest.

California absorbed 3.09 barrels ~~at~~ and 2.94 barrels of Portland cement, per capita in 1925 and 1926 respectively as compared with 1.66 and 1.79 barrels per capita for the State of New York for the same period. This signifies that California has now reached a period in her history where settled industries such as agriculture, manufacturing and mining have become stabilized and permanent. It also reveals the significant fact that Portland cement has been able to overcome the resistance offered economically, of wood and brick, both of which nature has bountifully, and in very large areas, supplied in the raw state.

Again in the northern and central parts of California, with which I am familiar, the raw materials include such a scope of geological variance, that this detail alone would constitute volumes. We find for the basic material, massive limestone, travertine and oyster shells. For the acid material, shale, fire clay, gumbo and ordinary clay.

The different methods of mining the raw materials include open pit mining, Glory Hole operation and dredging.

Again, there is the wide difference in the markets sefved by the cement companies in Northern and Central California with regards to climate. The mining districts are usually at from 3000 Ft. to 5000 Ft. elevation, with cool days and cold nights, and in some cases the concrete is mixed with water coming direct from the melting snow, while in the valleys below the temperatures may be 130° F with a low relative humidity. These extremes are not believed to be common to any other district and as a consequence the cement plants in this area must of necessity produce a quality of Portland cement above any ordinary standard.

In Northern and Central California, the last three plants erected have been the wet process and two of these plants embrace departures from ordinary practice that are of interest.

The Redwood City plant of the Pacific Portland Cement Company, obtain their raw material from the southern extension of San Francisco Bay.

The limestone occurs as oyster shells in very large areas throughout the southern end of the bay. In the flats they occur in the proportion of about 20% shells and 80% mud, and in the reefs that are formed principally by the ebb and flow of the tide in the channels, have very little mud associated. The method of winning is with a 16 inch Diesel powered suction dredge which operates to a depth of 30 feet. The dredge discharges into a barge about 100'Feet long and 30 feet wide having water tight sides and ends and about ten feet high. This water tight box is as near the full dimension of the deck barge as it is possible to make. The discharge from the dredge empties into the center of the barge at about 15 Ft. above the barge deck. Ports are built in the ends and sides of the barge, at different elevations. These ports have screens over them to catch the shells from loss. The speed with which they release or impound the mixture, (increasing or decreasing the residence of the material in the barge) determines whether the misture will be higher or lower in its mud content. This method of water classification is very efficient for this service.

It must be remembered that the raw mix is now saturated with the salt water from the bay. This must be diluted.

The raw mix (shells and mud) is now transported to the cement plant, placed by cranes in tanks, drawn off by screw conveyors and passed through a sand washer before being fed to the mills for grinding.

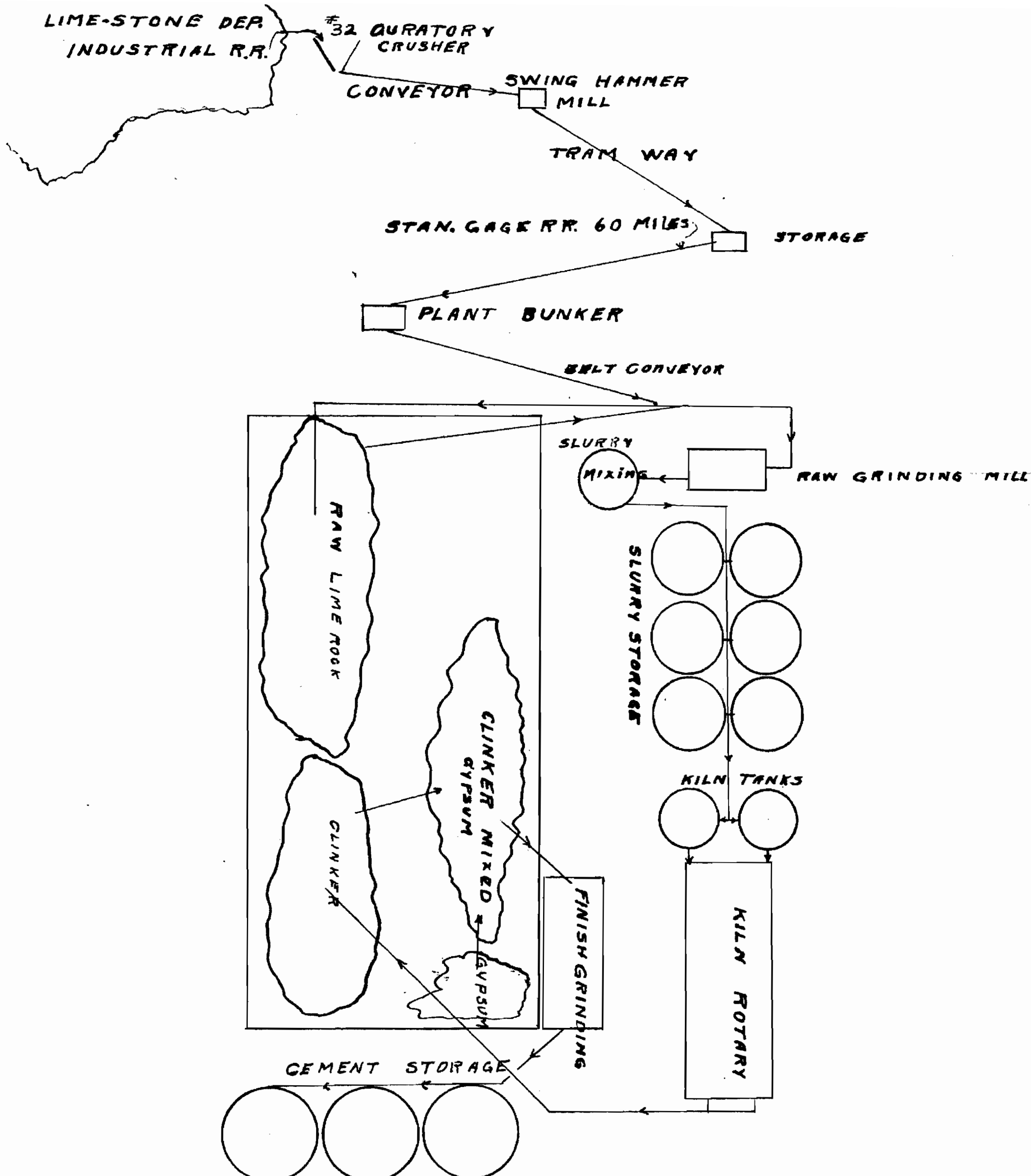
The sand washers are those of common design. The material is moved on an inclined screw conveyor, with tight sides and bottom and sprays of fresh water are gently played on the moving mass, care being taken not to use too much water and remove an excess of the necessary silt. The analysis of the shells show them to be about 92% $CaCO_3$, the remaining associated constituents being silica, iron and alumina with a small percentage of animal glue.

The material is now fed to the compeb mills for grinding. Control for lime content is affected in a rough measure at the barge, by water classification, and in the plant after the shells and associated bay silt is ground (slurry) by pumping and mixing volumetrically. The heat generated in grinding activates the animal glue in the shells, causing the resultant slurry to thicken. This colloidal action forces them to carry about 8% more water in their slurry to get a flowable mixture. The washing of the mixture in the sand washer, effects a dilution of the bay water fifty percent, and in the burning operation in the kiln, these salts can be seen, driven off as a fume, as each reaches its point of volatilization. From this point on the detail of plant, operation is similar to ordinary practice.

There are two cement plants that win their limestone by the Glory Hole method. The Santa Cruz plant having in my opinion a very simple and economical layout.

The quarry had previously been operated as an open face, with steam shovels as prime movers. After continued operation they had removed too much of the toe, and seasonal rains had lubricated the underlain and contact clay with disastrous results. The quarry equipment was covered and quarry operations were shut down for several months.

A tunnel was driven on the strike of the limestone and about 70 Ft. below the toe. Glory Holes are placed about every 100 Ft. leading into bull dozing chambers which are connected. By this method while the Glory Holes are not of very large capacity, they can easily be cleared in case of a plug. Drillers bench down the slope large blocks are drilled and shot and if any large pieces go into the bull-dozing chamber they are broken there. The storage chamber below the bull-dozing chambers are of several hundred tons capacity and are controlled with large radial gates.



FLOW SHEET YOSEMITE CEMENT MILL

The Yosemite Portland Cement Corporation's plant which is California's newest plant, is located two and one half miles north-west of Merced, Merced County. Their quarries are at Emory, a station on the Yosemite Valley Railroad, twenve miles west of Yosemite National Park, Mariposa County, California.

The limestone outcrops on the north bank of the Merced River, strikes northwest. The dip is 85° E. with an average width of 500 Ft. A transverse fault has cut the ledge as the limestone pitches down the hill, near the river. The main body of limestone which continues for 3000 Ft. has been opened up at an elevation of 800 Ft. above the Y. V. R. R. The incline as shown is 2000 Ft. long, the lower 1000 Ft. is on about a ten percent grade, while the upper 1000 Ft. changes to a 38° angle.

The quarry was opened on the east exposure, follows the strike and when fully developed the quarry face will be 500 Ft. high and 3000 Ft. long. The future operations may then be transferred to a lower level or continued across a ravine, along the same ledge. Drilling is done with Ingersoll Rand Jackhammers, air being supplied with two Ingersoll Rand 640 cu. ft. air compressors. The prime mover is a 32 Marion 1 1/4 Yd. electric shovel, loading into 6 Yd. standard gauge Western dump cars, moved by a 14 ton Plymouth gas locomotive.

The primary crusher is a #32 Allis Chalmers Gyratory, delivering to a Sheridan Grizzley, which removes the fines. The oversize is fed to a Williams Jumbo Hammermill that reduces to 3/4 inch. The crushed material is stored in a 600 ton bunker and moved up down the incline in 20 ton cars. Two cars are used on the incline, each on a separate track. A 1 3/8 inch steel cable, moved by a Wellman Seaver Morgan tandem driven hoist, connects the two cars, one end being attached to the car at the top of the hoist and the other end to the car at the foot of the hoist. The 200 H.P. motor for this hoist, moves supplies up to the quarry, but must act as a brake for lowering the loaded car.

The clay is obtained in Amador County, and is of the Ione formation. The clay analysis is as follows:

Sio	55.00	Dry basis
Al_2O_3	40.00	"
Fe_2O_3	1.80	"

Clay analysis (Continued)

CaO	1.85	Dry basis
MgO	.35	"

The clay is used by the local pottery plants, fire brick being manufactured from it. The clay is very smooth and plastic and when made into a slurry shows an exceptional particle fineness, much finer than 200 mesh. This clay is not ground but instead is mixed with 65% water in a clay wash mill, added to the ground limestone, the mixture of which is termed slurry.

The limestone is received at the plant in bottom dump cars, which discharge into a pit. a 24 inch belt conveyor carries the crushed limestone to the raw storage. The raw storage as shown is about 900 Ft. long and 70 Ft. wide, equipped with a three yard Erie Clam Shell Bucket.

The storage runs parallel to the kilns making it possible to move rock, clay, clinker and gypsum in and out of storage at will, also to unload the gypsum from the railroad cars for storage.

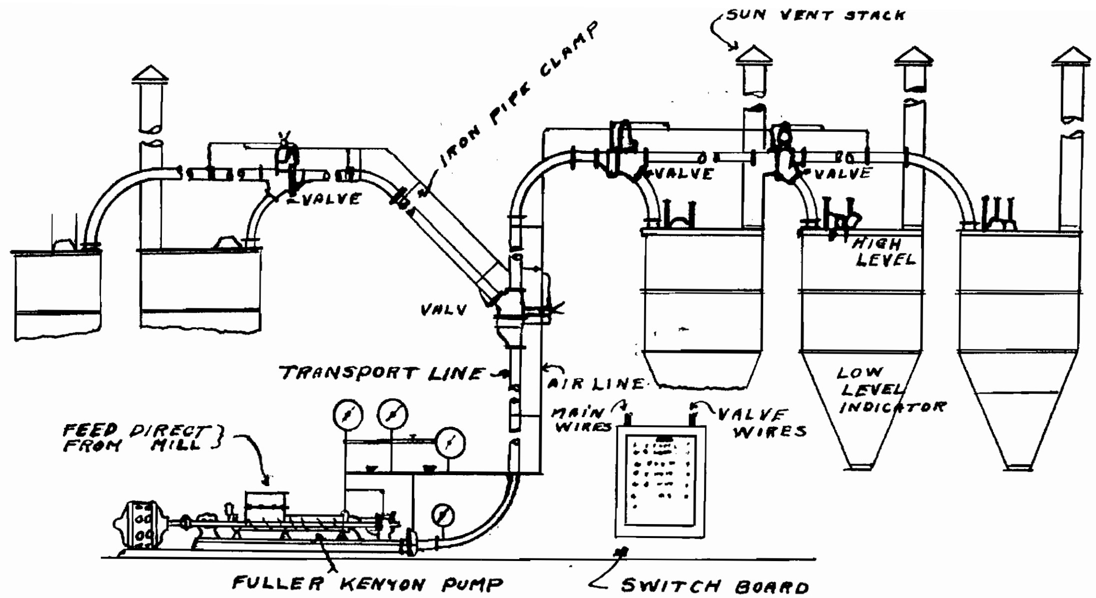
This storage is sufficient for 50,000 tons of limestone and clay, 100,000 barrels of clinker and several thousand tons of gypsum. All material is handled with an overhead crane having a speed of 450 Ft. a minute, with a lifting capacity of ten ton.

The raw mill equipment consists of two Allis Chalmers three compartment wet compeb mills, 7 Ft. by 26 Ft. driven by 500 h.p. A.C. 440-volt motors, directly connected by magnetic clutches. The slurry is pumped from the raw compeb mills with a 200 barrel per hour Wilfley pump into twelve slurry storage and correcting tanks. Each of these tanks has a capacity of slurry equal to 400 barrels of finished cement. These tanks are arranged so that the slurry may be drawn from any number of them at the same time and again pumped back into any of the twelve tanks, or it may be pumped into either of the two concrete kiln feed tanks which have a capacity of 800 barrels each. All slurry tanks are air agitated.

Two Allis Chalmers rotary kilns are being used. Each kiln is separately driven by a variable speed motor and is supported on four tires. A Ferris wheel feeder, direct connected to a variable speed motor that is operated from the burning end of the kiln, regulates the kiln feed. Each kiln has a concrete brick lined stack 205 Ft. high, giving a draft of 1.78 inches at 1100° F. with an inside diameter at the top of 10 Ft. A long horizontal flue between the kiln and stack serves as a dust collector. All dust is collected by a screw conveyor and elevated directly into the kiln feed pipe. Crude oil is used for firing the kiln. The oil is stored in an underground concrete resefvoir of 8000 barrels capacity. This reservoir is constructed so that the cars may be unloaded by gravity. Oil is received in tank cars which discharge the oil into a concrete trench from which the oil flows by gravity to storage. A pump delivers the oil to the kiln. The oil is heated by steam. For atomization, oil at two pounds pressure is used. One burner is used for each kiln and adjustments permit changing the direction, width and length of the flame easily. Both kilns are followed with an 8 by 100 foot Allis Chalmers cooler from which the clinker is carried by a cross belt conveyor to a double elevator, one being used as a stand-by. These elevators lift the clinker to the finish compeb mills bins, or by pass, to storage as may be required. This arrangement permits delivering all of the clinker to the grinding mill bins or to storage, or any proportion can be mixed with stored clinker as it is fed to the grinding mills. The cooler hood is specially designed and is supported on wheels similar to a kiln hood. It is made with a structural steel frame lined with fire brick and fits close to the cooler end and snug with the kiln firing floor, giving a practically airtight connection between the kiln and cooler.

The finish mill is equipped with two 7 by 26 Allis Chalmers compeb mills driven by the same size motors as those on the raw mill. These mills discharge to a Fuller Kinyon pumping system. This Fuller Kinyon pumping system delivers the cement through a 600 foot pipe line to the stockhouse, and consists essentially of a Fuller-Kinyon pump (See Page 17), which takes the material from the pulverizing mill to a storage bin through a conduit of standard 4 inch pipe; and two and three way valves, of the disc and port type, for controlling the flow of material through the branch lines to the various points of delivery. These valves may be operated both manually and be remote electric control, the latter being used in connection with operation from a central point.

It is well known that most dry powdered substances will flow and otherwise behave almost as liquids when mixed with a small amount of air. It appears that



TRANSPORTING CEMENT FROM MILL'S TO STORAGE BIN'S the solid particles become separated, each being surrounded by a film of air which considerable increases the volume of the mass and acts as a lubricant, greatly lessening both the internal friction and that against the walls of the conduit through which the mixture is forced.

Material fed to the hopper of a Fuller-Kinyon pump is advanced by an impeller screw through a hollow cylindrical barrel lined with wear-resisting renewable bushings. The bearings in which the screw shaft revolves are well protected against the entrance of dust, and the thrust of the screw is taken care of by a ball bearing of ample size. The impeller screw is protected with a layer of a wear-resisting alloy and the flights decrease in pitch towards the discharge end to compact the material to form a relatively dense seal, which is further augmented by a dead space or material seal beyond the terminal flight to the point of air admission. The air enters through a ring at this point. This ring is provided with a number of small orifices and is calibrated to admit the proper quantity of air for the specific installation. The pump discharges directly into the pipe line, which

which is laid in a trench to avoid interference with highways or railroad tracks, and which curves or bends as required to get around obstructions in its path. Changes in direction are made by long-radius pipe bends the radius being preferably five feet or more to reduce pipe friction and wear along the outside of the curve. Deliveries may be made to stationary bins, or to open box cars, specially equipped for handling bulk powdered materials.

The system should not be confused with pneumatic or blowing systems in which the material is transported more or less suspended in air. The small quantity of air used by the Fuller-Kinyon system serves primarily to aerate the material and create the liquid-like condition described above, and to reduce pipe friction to such a value that pumping may be done at a reasonable pressure. This small quantity of air produces comparatively little dust at the end of the line, so that it may be liberated from a receiving bin through a simple vent stack, without necessitating the use of a dust collector.

The stockhouse has a capacity of 60,000 barrels of cement and consists of four concrete silos each 32 Ft. in diameter and 60 Ft. high. It has one star bin and three interstice bins. Debinning is accomplished by means of screw conveyors which deliver to a bucket elevator, discharging to bins over the Bates packers. Four 3 tube Bates Packers have been installed for the present. The 4 Bates packers discharge to a common belt conveyor which loads directly to cars from both sides of the packhouse. Adjoining the packhouse and between the loading tracks is the bag storage and cleaning building, which is 54 by 152 Feet.

All the mill buildings are structural steel frame covered with galvanized iron sheets. They are provided with windows and ventilators. The motors are 3 phase, 440 volt, 60 cycle alternating current units. With the exception of the kiln and cooler drive, all motors are direct connected through herring-bone speed reducers. The necessary switching equipment is located in each department for motor control.

The quality of the cement manufacturer at this plant is outstanding and is indicated in the test as determined by the A. S. T. M. specifications, but best shown by its performance in concrete compression results. The 1:3 A. S. T. M. tensile results are:

3 Days	320 Lbs.		
7 Days	390 Lbs.	Compression	3000 Lbs.
28 Days	490 Lbs.	Compression	5000 Lbs.

In concrete compression this cement will make 50% of its design in three days and 80% of its design in seven days.

The standard specifications are:

Tensile	1: 3	7 Days	225 Lbs.
		28 "	325 "
Compression	1: 3	7 Days	1200 Lbs.
		28 "	2000 "

One of the major reasonf for this unusually high and early strength is due to the by-passing of the clay and grinding the limestone separately.

It requires 600 Lbs. of raw material to make a barrels of cement, made up approximately in the proportion of 80% limestone and 20% clay. By relieving the grinding units of this additional colume, they increase the yield in proportion and also they remove a material that coats and cushions the grinding medium. The limestone is as a consequence ground extremely fine, 92% passing through 200 mesh screen, and as the chemical reaction that takes place in the kiln at

2600° F. is dependent, to a very great extent, upon the surface areas of the combining materials. This extreme fineness no doubt gives a more complete reaction in the kiln, resulting in a harder and more fragile clinker.

The Yosemite Portland Cement Corporation's new plant has been the mecca for the world's cement manufacturing engineers for its simplicity of design and the outstanding quality of its cement.

YOSEMITE PORTLAND CEMENT CORPORATION, MERCED, CALIFORNIA - General View

YOSEMITE PORTLAND CEMENT CORP. MERCED, CALIFORNIA SHOWING OVERHEAD TRAM AND CLINKER STORAGE.

YOSEMITE PORTLAND CEMENT CORPORATION QUARRY, MARIPOSA COUNTY,- INCLINE

YOSEMITE PORTLAND CEMENT CORPORATION QUARRY, MARIPOSA COUNTY, - BUNKERS